952,039

PATENT SPECIFICATION

DRAWINGS ATTACHED

952,039

Date of Application and filing Complete Specification: Sept. 14, 1962.

No. 35138/62.

Application made in Germany (No. C25317 VIIa/8d) on Oct. 20, 1961.

Complete Specification Published: March 11, 1964.

Index at acceptance:—F4 G(1K, 2C5); D1 A(1D2B, 1D4A, 1DX)

International Classification:—F 26 b (D 06 f)

COMPLETE SPECIFICATION

Improvements in Washing Machines

We, CONSTRUCTA-WERKE G.M.B.H., a German body Corporate of Hansa-Allee 305, Dusseldorf-Oberkassel, Western Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to washing and spin-drying machines having a washing and drying drum mounted in a surrounding housing so that it is rotatable about a substantially horizontal axis. It also relates to methods of operating such machines.

With such washing and spin drying machines it is known to accelerate the drum from the washing speed to the spin-drying speed through an intermediate speed which remains constant for a short time. The machines have two driving motors, one being used to drive the drum at a low speed during washing and to accelerate the drum before spin-drying. To obtain the spin-drying speed, the washing motor is first operated and, after the maximum speed of this motor has been reached, it is disconnected and the spin-drying motor is started before the drum speed has dropped to any appreciable extent.

In such machines which are not anchored down, the drum and the surrounding housing sometimes together with the driving motors, are held in a frame in a resilient mounting so that they can vibrate. This is necessary in order to prevent the machine from becoming unstable as a result of uneven distribution of the washing in the drum during spin-drying. In any case, if the drum is to be operated at high speed, care must be taken to ensure that the washing is distributed as uniformly as possible over the inner surface of the drum. Particular care must be taken to ensure that this uniform distribution is brought about before the start of spin-drying.

With these washing and spin-drying machines which operate as centrifuges during spin-drying operations, it is necessary to avoid resonance of the rotating masses particularly if the masses rotating at different speeds of rotation, for example the drum and the driving motor, are rigidly connected together and the resultant system, in this example the drum system, is resiliently mounted in the machine frame. If the spin-drying speed is in the resonant range of the driving motor, damage to the machine is sure to occur sooner or later.

It is of course desirable to make the spin-drying speed sufficient to remove the maximum amount of water from the clothes. This speed cannot however be achieved in practice. With a speed sufficient to give a radial acceleration of 1000 g (1 g=9.81 metres per second per second) the remaining moisture is still about 33% of the dry weight of the washing. As the circumferential speed of the drum increases however, the power required by the spin-drying motor also increases, assuming that the maximum spin-drying speed is reached in a constant time.

The operation of the machine must therefore be a compromise which ensures that the clothes are distributed reasonably uniformly over the inner surface of the drum while at the same time keeping the driving power of the spin-drying motor within economic limits and avoiding resonance of the high-speed drum and the driving motor.

The requirements of the operation of the machine are:—

a) uniform distribution of the clothes over the inner surface of the drum before the speed is increased to the spin-drying speed;

b) avoidance of resonance in the normal spin-drying speed range of the drum and the driving motor;

c) maximum practical elimination of water from the washing;

d) driving motor power kept within acceptable limits and within the limits due to installation conditions.

With these requirements in view, a washing and spin-drying machine, comprising a drum which is rotatable about a horizontal axis in

an outer housing and has a diameter of between 450 mm and 550 mm, is operated by a method wherein the drum, when accelerated from the washing speed to the spin-drying speed has an intermediate speed which is kept constant for a certain period and imparts a radial acceleration of between 1.2 and 1.6 g to the outside parts of the washing in the drum whilst the water in the housing is pumped away until the surface of the water in the housing no longer wets the washing in the drum after which the speed is increased to a radial acceleration of between 270 and 400 g, the pumping away of water from the housing continuing during spin-drying.

By operating a washing machine in accordance with the invention, the washing will be substantially uniformly distributed around the drum before the high-speed spin-drying operation starts and therefore the resiliently mounted drum system can be kept steady even with a radial acceleration of between 270 and 400 g. Such an acceleration calls for a high circumferential speed for the drum in order to satisfy the condition of an optimum between the dryness of the clothes and the size of the driving motor, and in order to avoid resonance phenomena. It has been found that the water is eliminated from the clothes in dependence on the radial acceleration of the drum in the form of an exponential curve. The range from 270 to 400 g for the radial acceleration of the drum produces between 55 and 65% water elimination from the clothes. It has been found that there is no point in increasing the spin-drying speed further because, on the one hand, a further increase, for example to 900 g, gives a further improvement of only 15 in the water elimination while the driving power would have to be increased by more than double, and on the other hand resonance phenomena occur between the rotating drum and the driving motor. While the drum is rotating at the intermediate speed, the liquid contained in the washing drum ensures uniform distribution of the clothes provided that, in accordance with the invention, the radial acceleration of the washing drum is 1.2 to 1.6 g. The cycle of gyration of the clothes in this state of radial acceleration of the drum has a value which is only slightly below 1g, so that the washing only slightly comes away from the walls in the top part of the drum and on immersion in the liquid assumes a new position around the inner wall of the drum owing to the resistance of the water. This process takes place as the level of the water drops. When the level of the water has dropped to the bottom of the drum, the speed is raised to its maximum. During the acceleration of the drum to the final spin-drying speed, the water still in the outer housing acts as a heavy mass and prevents any excessive vibration of the drum, particularly as the drum passes through the critical speed range. Operation of the pump for removing water from the drum is continued so that the drum is emptied not before the attainment, but after passage through, the critical speed range.

According to a further feature of the invention, the drum is operated with a reversing action during washing, but is operated in just one preferential direction during its rotation at the intermediate speed. The preferential direction coincides with the direction of rotation last completed during the reversing washing operation. The spin-drying operation follows the intermediate speed without any pause and in the same direction of rotation.

In accordance with another feature of the invention, a washing and spin-drying machine for carrying out the novel method comprises a washing and spin-drying drum having a diameter of between 450 mm and 550 mm mounted so that it can rotate about a horizontal axis in an outer housing, a pump for emptying water from the drum and housing and a split-phase dual-speed motor which together with the housing is resilient mounted and which drives the drum through an infinitely variable speed coupling, so that in conjunction with the coupling, the motor can drive the drum at the washing, intermediate and spin-drying speeds, the pump being automatically switched on to commence emptying the housing and drum when the speed of rotation of the drum is changed over from the washing to intermediate speeds.

The motor is preferally operated with a varying direction of rotation during washing by a programme regulator and is switched to the intermediate speed by changing the motor poles through a conventional Dahlander circuit arrangement. The infinitely variable speed transmission which may include a belt drive ensures that the drum is driven at the spin-drying speed. The motor runs at a constant speed both when running at the intermediate speed and at the spin-drying speed. In this way three different speed ranges can be obtained for the washing and spin-drying drum with an extremely simple motor arrangement.

An example of the method and washing machine in accordance with the invention will now be described with reference to the accompanying drawings, in which:—

Figure 1 is a diagrammatic section through the drum of the machine;

Figure 2 shows a number of diagrams of the operations of the washing and spin-drying machine;

Figure 3 is a graph showing the effect of the drum speed or radial acceleration upon the residual moisture; and

Figure 4 is a diagrammatic plan of the washing and spin-drying machine.

Figure 1 shows the drum system which is mounted in the washing and spin-drying machine so as to be capable of vibration. The system consists of an outer housing 1 and a

perforated washing and spin-drying drum 2 mounted therein so as to be rotatable about a horizontal axis. A driving motor 3 is fixed to the outer housing. In this example, the drum system is suspended in the machine frame by springs 4 and is carried by shock-absorbers 5 from a baseplate 6. During spin-drying, the clothes 7 should be distributed as uniformly as possible over the inner periphery of the drum as illustrated. The total mass of the clothes may be imagined as being distributed around the circle of gyration 8. During washing, the liquid is kept at the level of the line 9 and is lowered to the level of the line 10 before spin-drying, that is while the drum is rotating at the intermediate speed. When the speed is increased for the spin-drying operation, the liquid 11 at the bottom part of the container acts as an inert mass. The level 10 continues to drop and the housing 1 is emptied before the maximum speed of the drum is attained.

In the diagrams in Figure 2, the abscissa is time showing the progress of the washing programme while in (a) the ordinate is the speed n of the drum. In (b) the ordinate is the delivery F of the drum emptying pump. In (c) the ordinate is the level of liquid s.

From Figure 2(a) it will be seen that during washing the drum is rotated at a low speed, for example 37—50 rpm, and with an alternating direction of rotation. The areas 12, 12^1 illustrate the movement of the drum during the washing operation. On completion of washing, the motor is switched to the higher speed by pole changing at the point 13, the pump also being put into operation, as shown in Figure 2(b). The intermediate speed, as shown at 14, is such that the radial acceleration in the circle of gyration 8 is kept slightly below that of gravity g. With a drum of radius r_1 of 230 to 260 mm, a value of 210 to 230 mm may be assumed for the radius of the circle of gyration. This condition is satisfied if a drum of radius r_1 of 250 mm is rotated at approximately 74 rpm. The water level, initially at the line 9, in the housing 1 drops continually whilst the drum rotates at the intermediate speed. The clothes are drawn apart by the resistance of the water and at this specific speed are distributed substantially uniformly over the inner periphery of the drum. When the level of liquid has dropped to the periphery of the drum, as indicated by the level line 10 and the point 15 in Figure 2(c), then as indicated at 16 in Figure 2(a) the drum speed, as will be indicated in detail hereinbelow, is increased to 1,000 rpm and more, as shown in broken lines at 18 in Figure 2(a) is kept constant in these conditions, the increase in the drum speed being produced by an intermediate drive.

As shown in Figure 3, the x-co-ordinate represents the speed of rotation of the drum during spin-drying and the y-co-ordinate the residual moisture as a percentage of the dry weight of the washing. The calculations are based on a drum of a radius of 250 mm. The curve shown in Figure 3 thus corresponds to a function of n or g. The motor for the drum is a pole-changing dual-speed motor controlled by a Dahlander circuit arrangement and preferably rotates at two speeds, namely 1500 rpm during washing and 3000 rpm during spin-drying. When the drum is operated for spin-drying, care must be taken to ensure that the frequencies of rotation of the drum on the one hand and of the motor on the other hand are not resonant. The driving motor is of the asynchronous type so that changes in speed are to be expected during spin-drying. The magnitude of these changes differs according to the loading and is normally not more than 10%. The half-frequency $\frac{1}{2}f$ is 1500 rpm, the range of discontinuity due to asynchronous running extending as far as 1350 rpm. The next harmonic frequency is $\frac{1}{4}f$ at 750 rpm, the range of discontinuity being -75 rpm. These discontinuity ranges are shown shaded with horizontal lines in Figure 3. To ensure smooth running these ranges must be avoided. The optimum speed for spin-drying is an integral mean value between the zones illustrated by the vertical lines 19, 20 and the horizontal line giving the areas 21 and 22. The point of intersection 25 of the horizontal line 23 and the curve 24 gives an optimum speed of approximately 1050 rpm, as shown by the vertical line 26. At this point the radial acceleration is approximately 295 g. As a result of the asynchronous operation, however, this optimum speeed may fluctuate by $\pm$ 10%, corresponding to an acceleration in the range from 260 to 360 g. At the point of intersection 25 the elimination of water from the clothes corresponds approximately to 60% residual moisture. If a much lower residual moisture is to be obtained, the speed would have to be increased at least to 1600 rpm in order to escape the critical range of the harmonic frequency, while the increase of about 600 rpm would give only a 15% improvement in residual moisture and yet the driving power would be more than doubled. The result would therefore be out of all proportion to the expenditure. It has been found that with a machine with the above-mentioned drum size there is really only one optimum spin-drying speed range which has an optimum value and at which a resonant rise of the vibrations of the rotating masses is reliably avoided.

As shown in Figure 4, the single driving motor 3 carries on a driving shaft 27 an adjustable V-belt pulley 28 which is in line with a similarly adjustable V-belt pulley 29. Connected to the pulley 29 is a belt transmission consisting of belt pulleys 30 and the pulley 31 driving a shaft 32 fixed to the drum. A servo motor 33 engages and disengages, by means of

a lever 34, the halves 35 and 36 of the belt pulley 28. The halves of the belt pulley 29 follow the movement in the reverse direction as is usual. The motor 3 is operated by way of leads 37 at a low speed of 37 rpm, during washing. Two of the current phases are periodically changed over by a reversing unit 38 so that the motor 3 is operated with a reversing action. After washing has been completed, the current phases 37 are disconnected by the programme regulator and the motor is energised by way of leads 39. The driving motor 3 now operates with a small number of poles, the speed of rotation being increased to 3000 rpm. The variable transmission, consisting of the pulleys 28 and 29, operates as a step-down transmission in the first instance. As a result of the increased motor speed the drum is operated at twice the speed of rotation during washing and now rotates at 74 rpm. The radial acceleration of the clothes at this drum speed is approximately 1 g, allowing for the mass distribution. Simultaneously with the changeover of the driving motor 3 to the higher speed the pump motor 40 is also switched on so that the level of liquid drops from the level line 9 to the level line 10 and further. As soon as the level of liquid in the housing and drum has dropped to the bottom of the drum, i.e. to the level line 10 so that the surface of the water no longer wets the washing in the drum, a switch consisting of contacts 42 and 43 is closed and this starts the servo motor 33. The switch is closed by means of a Pitot tube 41 which communicates with the bottom of the housing and as the level of water in the housing and tube changes, the pressure of air trapped in the tube above the water level transmits a variable force to a diaphragm which is connected to the contact 43. When the water level and hence the air pressure drop sufficiently, the contact 43 is lowered onto the contact 42 to close the switch. The two-armed lever 34 moves the pulley halves 35 and 36 towards one another as illustrated so that the belt runs on the periphery of the pulley 28 and on the hub of the pulley 29 and the coupling acts as a step-up transmission. The drum is now accelerated to a radial acceleration of approximately 260 to 320 g for the clothes. During spin-drying the pump motor 40 is kept in operation so that the housing 1 is empty just after the maximum speed is reached. After completion of spin-drying the programme regulator causes the servo motor 33 to operate in the reverse direction so that the pulleys 28 and 29 are moved back. The machine is ready for operation for the next washing operation or a subsequent washing stage of the same operation.

The servo motor 33 and the adjustable pulleys 28 and 29 may be replaced by other variable speed transmissions. The adjustment of the belt pulleys can also be produced by a hydraulic or magnetic device. The important factor is that one motor is used to drive the drum with a reversing action during washing and at an elevated speed after washing, and, by means of an adjustable or engageable intermediate drive, to drive the drum at the maximum spin-drying speed. The driving motor 3 operates at a constant speed both during the intermediate speed operation and the spin-drying operation.

The method according to the invention ensures smooth running of the machine. The vibrations transmitted to the ground at the place where the machine is used can, however, be further reduced by using hydraulic or air cushions instead of the otherwise conventional supports. The washing and spin-drying machine rests on supports 44 comprising hydraulically extensible plungers.

As soon as the machine is connected to a cold water pipe by way of a hose 46, water flows through a pipeline 47 to the supports 44, the plungers 45 being extended and wheels 48 being lifted from the ground. Vibrations occurring during operation are taken by the plungers 45, the pressure fluctuations in the plungers due to vibrations or knocks being conveyed through a conduit 47 to the hose 46. The flexible hose thus contributes to reducing the vertical vibrations transmitted to the floor. This surprising effect in conjunction with the steps for reducing unbalance at high spin-drying speeds gives a smooth vibration-free operation of the washing and spin-drying machine under economic driving conditions and with optimum elimination of water from the clothes.

WHAT WE CLAIM IS:—

1. A method of operating a washing and spin-drying machine comprising a drum which is rotatable about a horizontal axis in an outer housing and has a diameter of between 450 mm and 550 mm, wherein the drum, when accelerated from the washing speed to the spin-drying speed has an intermediate speed which is kept constant for a certain period and imparts a radial acceleration of between 1.2 and 1.6 g to the outside parts of the washing in the drum whilst the water in the housing is pumped away until the surface of the water in the housing no longer wets the washing in the drum after which the speed is increased to a radial acceleration of between 270 and 400 g, the pumping away of water from the housing continuing during spin drying.

2. A method according to claim 1, in which the drum is operated with a reversing action during washing, and is rotated at the intermediate speed in the same direction as that last occurring in the washing operation, the spin-drying operation following the rotation at the intermediate speed without any pause and in the same direction of rotation.

3. A method according to claim 1, substantially as described with reference to the accompanying drawings.

4. A washing and spin-drying machine for carrying out the method in accordance with claim 1, the machine comprising a washing and spin-drying drum having a diameter of between 450 mm and 550 mm mounted so that it can rotate about a horizontal axis in an outer housing, a pump for emptying water from the drum and housing and a split-phase dual-speed motor which together with the housing is resilient mounted and which drives the drum through an infinitely variable speed coupling so that in conjunction with the coupling, the motor can drive the drum at the washing, intermediate and spin-drying speeds, the pump being automatically switched on to commence emptying the housing and drum when the speed of rotation of the drum is changed over from the washing to intermediate speeds.

5. A machine according to claim 4, in which a servo motor which operates in dependence upon the water level in the housing controls the infinitely variable speed coupling.

6. A machine according to claim 4, substantially as described with reference to the accompanying drawings.

For the Applicants,
GILL JENNINGS & EVERY,
Chartered Patent Agents,
51/52, Chancery Lane, London, W.C.2,

Leamington Spa: Printed for Her Majesty's Stationery Office, by the Courier Press (Leamington) Ltd.—1964. Published by The Patent Office, 25 Southampton Buildings, London, W.C.2, from which copies may be obtained.

Fig.1

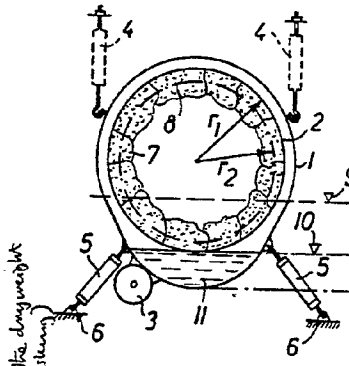


Fig.2

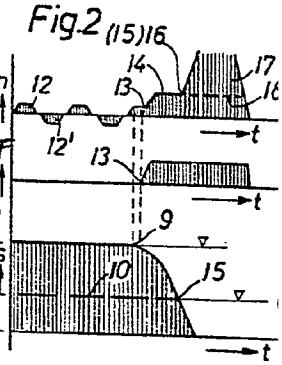
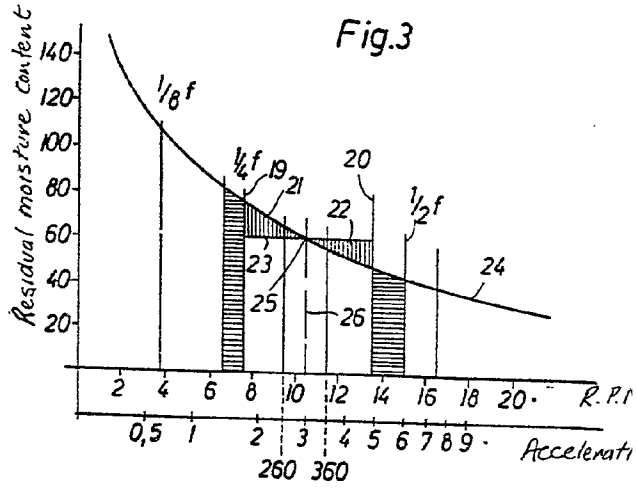


Fig.3



952039 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheets 1 & 2

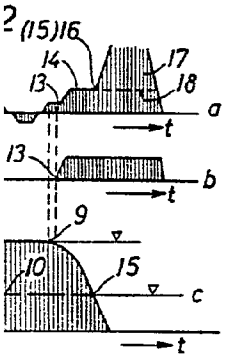
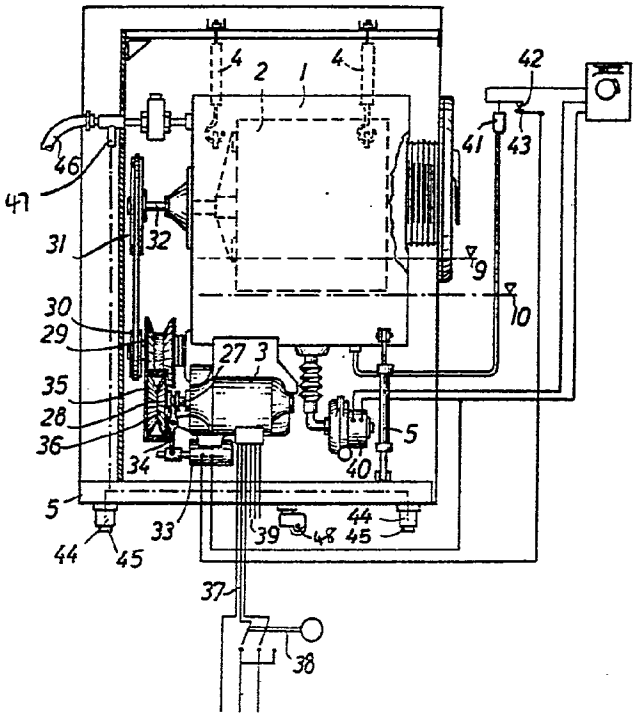
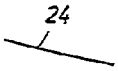
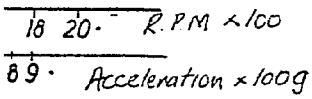


Fig.4







952039 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheets 1 & 2

Fig.1

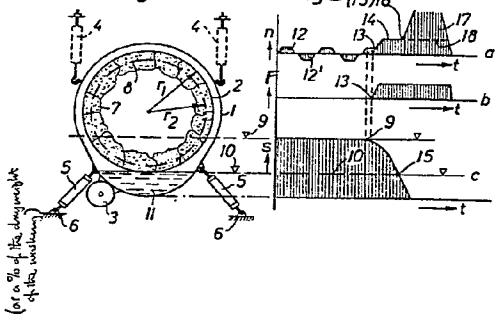


Fig.2

Fig.3

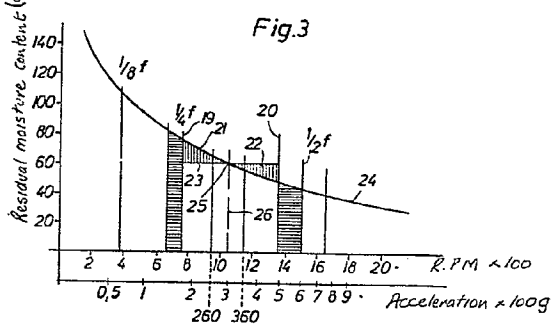


Fig.4